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## Exclusive production of $\rho^0\rho^0$ pairs in ultrarelativistic heavy ion collisions

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We discuss exclusive electromagnetic production of two neutral  $\rho^0$  mesons and show the predictions for the  $AA \rightarrow AA\rho^0\rho^0$  reactions for gold-gold collisions at the energy of  $\sqrt{s} = 200$  GeV (RHIC) and for lead-lead collisions at the energy of  $\sqrt{s} = 5.5$  TeV (LHC). The elementary cross section is calculated with the help of the vector-dominance-model (VDM)-Regge approach which usually very well describes the experimental data at large  $\gamma\gamma$  energy. The low-energy  $\gamma\gamma \rightarrow \rho^0\rho^0$  cross section is parametrized. The cross section for nuclear process is calculated by means of the equivalent photon approximation (EPA). We compare the results with realistic charge density with the results for monopole form factor.

*Keywords:* exclusive production;  $\rho^0$  mesons; monopole and realistic charge form factor.

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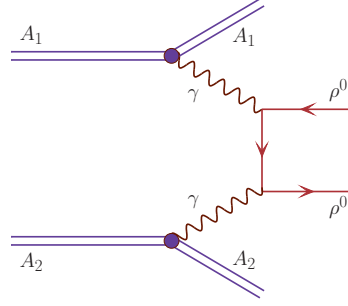
### 1. Introduction

Fig. 1 shows the basic mechanism of the exclusive electromagnetic meson pair production. Two neutral  $\rho$  mesons are produced in coherent photon-photon processes in ultrarelativistic heavy-ion collisions. So far only  $AA \rightarrow AA\rho^0$  was measured<sup>1</sup> and estimated in the literature. We consider collisions at RHIC and at LHC, where RHIC collides gold ions at the energy of 200 GeV and LHC will collide soon lead nuclei at the energy of 5.5 TeV per nucleon.

### 2. Formalism

EPA is very often used for calculating cross sections for electromagnetic interactions. Due to the coherent action of all the protons in the nucleus, the ions are

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Fig. 1. The Born diagram for the exclusive  $\rho^0$  pair production.

surrounded by a strong electromagnetic field. This field can be viewed as a cloud of virtual photons which can collide with each other. This approach allows to consider production of mesons in peripheral ultrarelativistic nuclear collisions. “Peripheral” means that the distance between the nuclei is in practice bigger than the sum of the radii of the two nuclei ( $b > R_1 + R_2 \simeq 14$  fm). The total cross section in EPA takes the form of the convolution of the elementary cross section ( $\gamma\gamma \rightarrow \rho^0\rho^0$ ) and the equivalent photon fluxes:

$$\sigma(AA \rightarrow \rho^0\rho^0 AA; s_{AA}) = \int \hat{\sigma}(\gamma\gamma \rightarrow \rho^0\rho^0; x_1 x_2 s_{AA}) dn_{\gamma\gamma}(x_1, x_2, \mathbf{b}). \quad (1)$$

We have introduced a new kinematical variable:  $x = \frac{\omega}{E_A}$ , where  $\omega$  is the energy of the photon and the denominator is the energy of the nucleus. After several transformation, we obtain the final form for the nuclear cross section in EPA:

$$\begin{aligned} \sigma(AA \rightarrow \rho^0\rho^0 AA; s_{AA}) &= \int \hat{\sigma}(\gamma\gamma \rightarrow \rho^0\rho^0; W_{\gamma\gamma}) \theta(|\mathbf{b}_1 - \mathbf{b}_2| - 2R_A) \\ &\times N(\omega_1, \mathbf{b}_1) N(\omega_2, \mathbf{b}_1) 2\pi b_m db_m d\bar{b}_x d\bar{b}_y \frac{W_{\gamma\gamma}}{2} dW_{\gamma\gamma} dY, \end{aligned} \quad (2)$$

Here we put the  $\theta$  function which assures only peripheral collisions. In addition we define:  $Y = \frac{1}{2}(y_{\rho^0} + y_{\bar{\rho}^0})$ ,  $\bar{b}_{x/y} = (b_{1x/y} + b_{2x/y})$  and  $b_m = \vec{b}_1 - \vec{b}_2$ . The details of the derivation of Eq. (2) can be found in our recent paper <sup>2</sup> on the muon pair production in the same approach.

The elementary cross section is divided into two components <sup>3</sup>. The low-energy part is parametrized and the parameter are fitted to the  $e^+e^-$  data <sup>3</sup> while the high-energy part is obtained with the help of the vector-dominance Regge type model with the parameters <sup>4</sup> which are used to described other hadronic processes .

The equivalent photon spectra (see Eq. (2)) depend on the charge form factor of nuclei. The realistic form factor is the Fourier transform of the realistic charge distribution:

$$F(q) = \int \frac{4\pi}{q} \rho(r) \sin(qr) r dr. \quad (3)$$

In the literature often a monopole form factor is used:

$$F(q^2) = \frac{\Lambda^2}{\Lambda^2 + q^2}. \quad (4)$$

The two form factors coincide only in a very limited range of  $q$ . With a larger value of the momentum transfer the difference between them becomes larger and larger. Inclusion of the realistic form factor becomes particularly important at large meson pair rapidities<sup>3</sup>.

### 3. Results and Conclusions

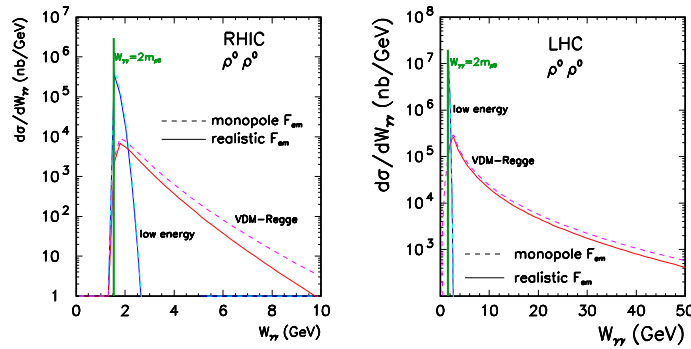


Fig. 2. The cross section for  $Au - Au$  (left panel) and for  $Pb - Pb$  scattering as a function of photon-photon center of mass energy  $W_{\gamma\gamma} = M_{\rho^0\rho^0}$ .

Fig. 2 shows the distribution of the cross section for the nucleus-nucleus scattering in the photon-photon center of mass energy  $W_{\gamma\gamma}$  (i.e. the pair invariant mass) for both the low-energy component and high-energy VDM-Regge component. This distribution should be relatively easy to measure. The distributions in the impact parameter or in the rapidity of the pair (not shown here) also show that the low-energy component is the dominant one. The cross section obtained with the help of the monopole form factor is larger than that obtained from the realistic charge form factor. In addition we have observed that for smaller center-of-mass energy the difference between the realistic and monopole form factor is bigger.

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